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Design, Construction And Implementation Of Temperature Control In Vapor-Liquid Equilibrium Cell (VLE)

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ABSTRACT: This article talks about the design and implementation of a thermal control in vapor-liquid equilibrium cell (VLE). Including integration of an amplifier circuit instrumentation for sensing stage by a thermocouple in conjunction with a full wave rectifier controlled. This controller used as a single-phase power line AC voltage which will be rectified to supply the voltage used by a thermal blanket and this transform electrical to thermal energy. The temperature generated by the heater blanket will depend on the way to generate this contact with the surface to be heated and the insulation used. The display operation of the control signals will be on a computer with the LabVIEW platform using an Arduino UNO which function as a data acquisition card. EVL cells are important in obtaining thermodynamic properties.

KEYWORDS: Arduino, vapor-liquid equilibrium cell, thermal control, LabVIEW

I. INTRODUCTION

Good thermal control is necessary to study and obtain thermodynamic properties. This information is essential for development, construction and optimization of laboratory equipment for chemical and industrial processes. For example in biotechnology area the organic compounds are sensitive to temperature change, which are necessary to separate as pure as possible without damaging its elements or generate undesirable agents.
Actual equipment are expensive because of their specialization for certain characteristics of working substances, such equipment can not be easily adapted if those conditions are altered or different from their pre-established substances. To solve this problem a power circuit which transform electrical to thermal energy using the arduino free platform as controller and dynamic control to the characteristics of different substances proposed study.

II. IMPLEMENTATION OF DRIVER

Converting AC to DC is important because of the facility of control, second important factor is the correction coefficient converting direct current (DC). This conversion is slower, therefore facilitates control, the downside of this is the maximum temperature reached is less than 100 ° C. The alternating current (AC) instead allows a higher temperature but this temperature increases rapidly preventing well control. The block driver control and thermal reading in Figure 1 are simply separated by the data flow between them. But on the control board are together because they need each other to function properly.

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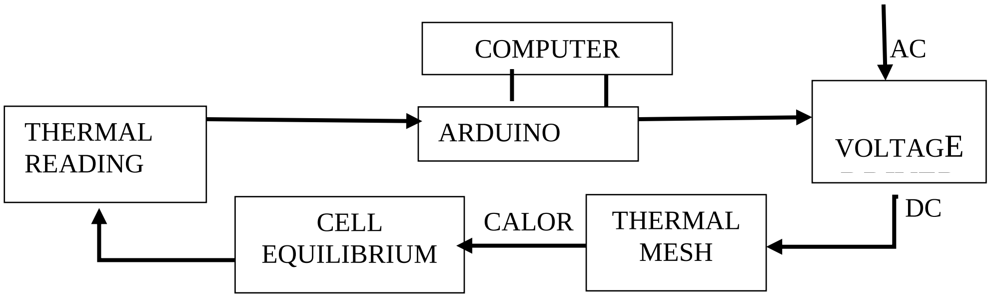

Figure 1: Control block diagram.

The step of sensing requires a dual source for supplying an instrumentation amplifier, which increases the signal generated by the thermocouple into a signal capable of being recognized by the Arduino. In the same way is a coupling impedance between the sensor and reading the arduino. In Figure 2 shows the complete circuit.

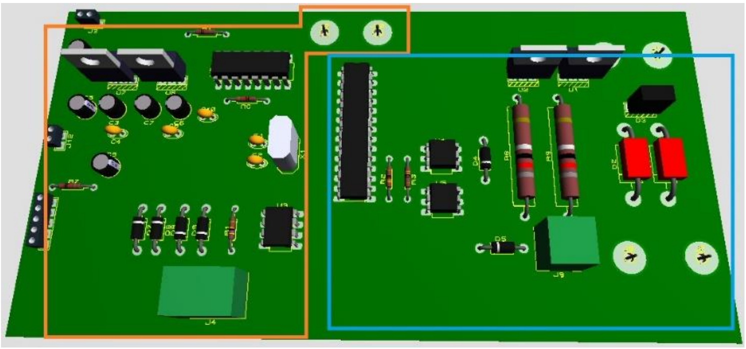

Figure 2: Orange box represents the step of sensing and the blue box the rectifier circuit.

III. PARAMETRIZATION AND ISOLATION

The behaviour of the conversion of electrical energy to thermal energy is not linear, preliminary tests were performed. Heat produced by the thermal mesh (element energy conversion) depends on how this is placed in the cell equilibrium. Whereby at the end of the tests determined the best option would be to wrapping the cell and isolate it by a layer of aluminium and a polyethylene foam layer.

With the isolation energy loss is minimal, in some ways is despicable. Heat is supplied to the cell equilibrium maximizing power conversion. With this an unusual phenomenon, as the temperature is not proportional to the supply voltage, the control program should take into account this increases the temperature gradually without exceeding the desired upper limit occurs.

For this study are use a type J thermocouple. That has a good sensibility for this prototype. Its size is important. If the thermocouple is small the temperature recorded only be one phase. But it is very large will protrude from the equilibrium cell generating a signal interference to register in the controller.

The driver for this project is based on a PID control to calculate the required earnings data heating were captured in open loop, using the software MathLab. These data were equation approximate transfer and calculate their respective control gains.

IV. RESULTS

In this investigation were studied pure and binary mixtures of water, methanol and ethanol in a volume fraction of 50% v/v. Features like atmospheric pressure and ambient temperature affect the boiling point of substances. Standardized boiling point values are based on the repeatability of results at a constant pressure, at constant pressure and an ambient temperature of 20 ° C.

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The project was conducted in the city of Celaya, Guanajuato. This city is located at an average of 1720 m respect to the sea level. For several studies have a decremental ratio of 0.5 degrees per 150 m elevation. Thus to calculate the boiling temperature the following equation was used.

$$T_e = T - \left(\frac{Altitude}{150} * 0.5\right)$$

For reasons of sequencing the first tests and results were obtained with pure substances which control ethanol showed a linear behavior, with a slight fluctuation in their values, in Figure 3 the allowed limits is observed with an error of 0.1 degrees .

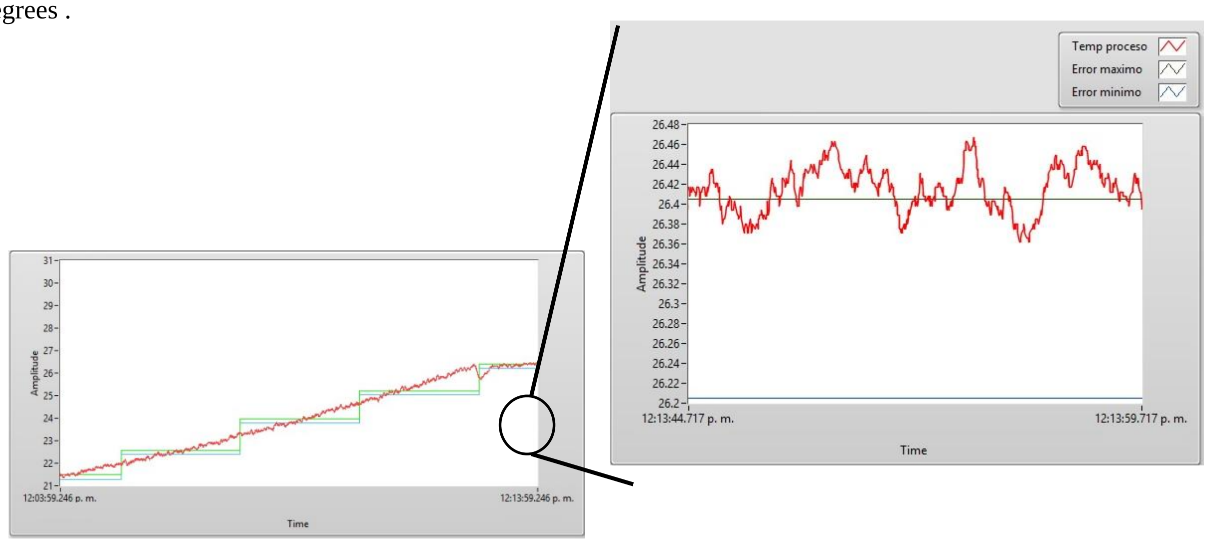

Figure 3: High limit the temperature control.

The behavior of methanol is fluctuating. But the increase was 3 degrees in 10 minutes. The surplus ranges actually are due to the sensitivity of the sensor. Measurements recorded as shown in Figure 4.

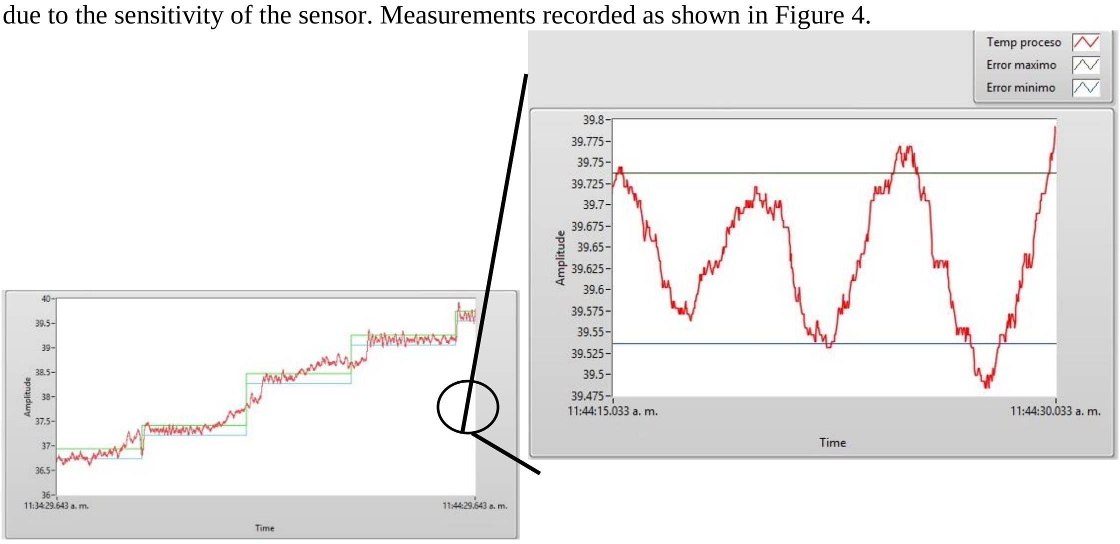

Figure 4: Methanol analized within the established ranges.

The more stable control was obtained with binary mixture of water-ethanol. This graphic shows the fluctuating like a heating in two stages. Measurements recorded as shown in Figure 5.

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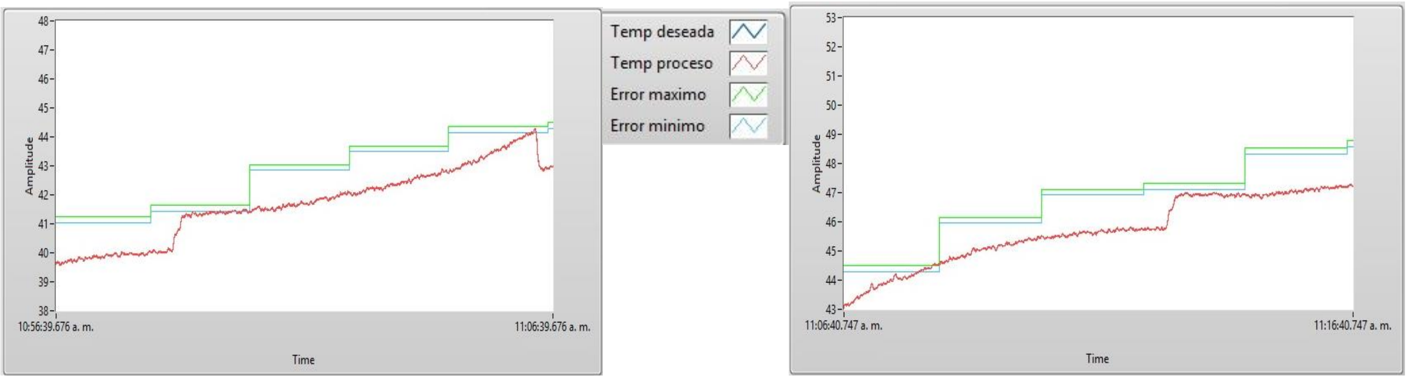

(a) **(b)**

Figure 5: The behavior of water-ethanol respect de increase o temperature.
a) heating chaotic and b) controlled heating.

Compared with other mixtures the control binary mixture water-ethanol was one of the most chaotic to exceed 39 ° C. The Figure 6 shows this behaviour.

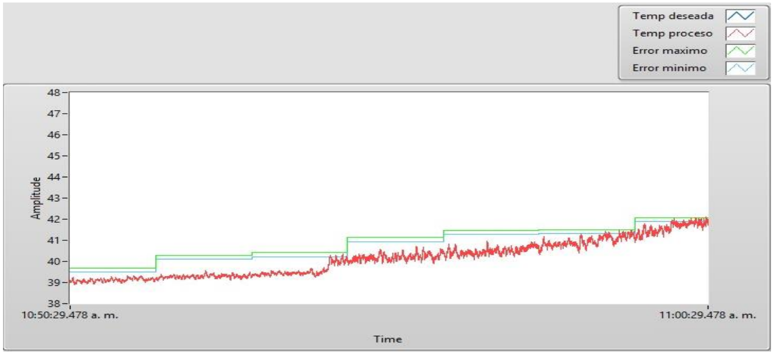

Figure 6: Fluctuations increasing with temperature increase.

The fluctuations in the signal are caused to this solution presents an azeotropic behavior. The molecules of the two original substances behave as if they belonged to a single substance. In Figure 7 it can see the behavior trying to stabilize.

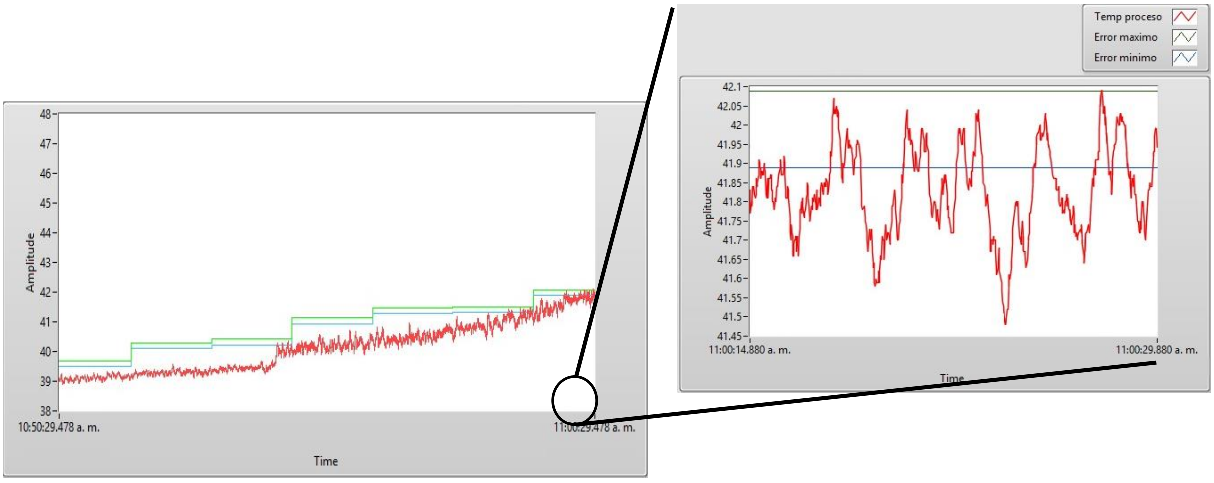

Figure 7: Behavior of temperature control.

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VI.CONCLUSION

In this study was observed an intrinsic error in the acquisition of the temperature signal because of behaviour of these substances an intermolecular level. This ramping is fluctuating but within the control ranges. The size of the thermocouple is a factor to consider in this project since the length thereof is larger than the cell balance, exceeding one end which will be affected by the ambient temperature. Because if this is too large and not isolated its part in contact with the ambient. The control has too much instability.

One of the objectives of this work was to have a time constant stability, but this will be dictated by the difference in initial temperature and the desired temperature, set a time average of stability it is complicated. Study substances have different chemical characteristics. The boiling point is the main factor. In binary mixtures the boiling point is determined by the concentration of substances

Dynamic control described in this investigation facilitates the study of binary mixtures, ternary, quaternary, etc. as well as the understanding of the behaviour of pure substances. The controller could be the basis for the design of controllers specialized vapour-liquid equilibrium cells.

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